

TITLE

Scanning Treatment Laser

FIELD OF INVENTION

[0001] This invention relates generally to medical devices that employ lasers. More particularly, this invention relates to a treatment laser device that incorporates a scanning head to deliver a beam spot of any shape.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] This application claims the benefit of U.S. Patent Application 09/932,907 filed August 20, 2001, which claims the benefit of U.S. Provisional Application No. 60/273,282 filed March 2, 2001.

BACKGROUND

[0003] Low level laser therapy (LLLT) utilizes low level laser energy in the treatment of a broad range of conditions. LLLT improves wound healing, reduces edema, and relieves pain of various etiologies, including successful application post-operatively to liposuction to reduce inflammation and pain. LLLT is also used during liposuction procedures to facilitate removal of fat by causing intracellular fat to be released into the interstice. It is also used in the treatment and repair of injured muscles and tendons.

[0004] The LLLT treatment has an energy dose rate that causes no immediate detectable temperature rise of the treated tissue and no macroscopically visible changes in tissue structure. Consequently, the treated and surrounding tissue is not heated and is not damaged. There are a number of variables in laser therapy including the wavelength of the

laser beam, the area impinged by the laser beam, laser energy, pulse width, treatment duration and tissue characteristics. The success of each therapy depends on the relationship and combination of these variables. For example, liposuction may be facilitated with one regimen utilizing a given wavelength and treatment duration, whereas pain may be treated with a regimen utilizing a different wavelength and treatment duration, and inflammation a third regimen. Specific devices are known in the art for each type of therapy.

[0005] An earlier patent, United States patent number 6,013,096, describes a hand-held wand that houses a red semiconductor laser and optics to deliver the beam from the laser to the skin of a patient. A simple timing circuit is provided for controlling the length of time a laser beam is emitted from the wand. An optical arrangement causes the emitted light to form a line on the patient's skin, the shape of the light as it impinges the patient's skin referred to herein as the beam spot.

[0006] Reference may also be had to our co-pending application 09/932,907 which describes a device that delivers two or more laser beams with different characteristics to treat a patient for multiple types of problems during a single treatment. The patent application describes a hand-held wand that houses a plurality of laser energy sources and optics to direct laser beams from the sources to a patient. Control electronics are provided to vary such parameters as the pulse repetition rate. Optics are also provided to select the beam shape of the laser output, which in turn determines the beam spot.

[0007] Both of these devices rely on a static optical arrangement to produce a beam spot. Neither of the devices provides a means for varying the shape of the beam spot on demand nor for automatically varying the resultant intensity. It has become clear in LLLT

that there is benefit in being able to customize the delivery of the laser light treatment by changing the shape and energy distribution of the delivered beam spot.

[0008] Therefore, an object of this invention is to provide a laser therapy device that enables shaping of the delivered laser beam to suit multiple types of treatments. It is a particular object of this invention to provide a hand-held therapeutic laser device to provide low level laser therapy which can be used to treat injured muscles and tendons, facilitate liposuction, and treat post-operative inflammation and pain.

SUMMARY OF THE INVENTION

[0009] This invention is an improved laser device that can deliver a desired beam spot to a treatment area and to provide multiple types of low level laser therapy treatments. The device enables laser light of any beam spot and intensity to be applied externally to a patient's body. The device utilizes a means for causing the laser to scan rapidly and may include multiple laser sources.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a schematic illustration of a preferred embodiment of the present invention.

[0011] FIG. 2 is a side view of a scanning head of the preferred embodiment of FIG. 1.

[0012] FIG. 3 shows examples of beam shapes achievable with the present invention.

[0013] FIG. 4 is a schematic illustration of application of low-level laser radiation using the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Referring to the drawings, there is illustrated a schematic of a hand-held laser device designated generally as 10. The device includes at least one laser energy source 11, a power source 12, a laser control 13, a scanning head 14, and a scanner control 15. FIG. 1 shows the preferred embodiment in which a laser energy source 11 is connected to a power source 12. The power source preferably provides direct current, such as that provided by a battery, but may instead provide alternating current such as that provided by conventional building outlet power (120V) that is then converted to direct current. The power supply 12 may be housed in the wand or may be deployed separately with an electrical cable joining it to the wand. A control means 13 is connected to the laser energy source 11 and acts as on/off switch to control the period of time the laser light is generated. Other functions of the control means 13 are mentioned below.

[0015] A scanning mechanism directs the laser beam emitted from the laser source 11 to any position on the patient. In the preferred embodiment, the laser beam emitted from the laser source 11 is directed to the scanning head 14 which deflects the laser beam into any position within a hemisphere in front of the scanning head, as depicted by the lines 16. With electronic or computerized control, the scanning head is able to automatically move very quickly, causing the laser beam to appear to create any static shape on the patient's skin. The static shape, however, is actually the result of the scanning light moving from location to location at a speed that makes the motion nearly

imperceptible to the human eye. In this way any desired shape of light can be achieved, regardless of the actual cross-sectional shape of the laser beam. If the laser is directed to scan across one area more than another, the intensity of the laser therapy is greater in the area of high scan.

[0016] A preferred structure for the scanning head 14 is shown in FIG. 2. The scanning head comprises a hollow spindle 20 mounted on a hollow shaft 21. The laser beam passes through the hollow shaft 21 and strikes an optical element 22 which deflects the laser beam into a desired location. Although the optical element is shown as a prism in the preferred embodiment it will be appreciated that a mirror could also be used. The optical element, referred to hereinafter as prism 22, is mounted on a transverse axle 28 so that it can rotate through at least 180 degrees. In some applications a lesser degree of travel may be sufficient. The position of the prism 22 is controlled by a hinged drive arm 23 connected to the prism at one end and a cam 24 at the other end. The cam 24 is able to travel along the spindle 20 thus causing rotation of the prism 22. Furthermore, the spindle 20 is able to rotate on the shaft 21. The combination of the rotation of the spindle 20 and movement of the cam 24 positions the prism so as to direct the laser beam into any position within a hemisphere in front of the scanning head.

[0017] The position of the prism may be controlled by micromanipulators according to signals received from the scanner control 15. Any suitable mechanism may be employed but in the preferred embodiment a motor 25 rotates the cam 24 and a solenoid 26 extends (retracts) the cam longitudinally. The combination of rotation and extension of the cam controls the position of the prism or mirror. It will be appreciated that both these functions could be provided by a single micromanipulator acting on the cam 24.

[0018] While the preferred embodiment utilizes the scanning head 14, other mechanisms for causing laser scan may be used, such as raster scanners like galvanometers, rotating mirrors, speaker scanners; also diffraction grating rotators, light diffusers and the electronics necessary to generate and control image patterns.

[0019] The scanner control 15 is programmed to move the scanning head 14 in a required manner to achieve any desired shape of a treatment zone on the skin of a patient. A sample selection of available shapes is shown in FIG. 3. It will be appreciated that the range of available shapes are not limited to those shown in FIG. 3.

[0020] Furthermore, the scanner control 15 can be programmed to direct the laser output into some regions more than others so that one region may have greater treatment than another region. For example, a donut shaped beam may be produced with less energy delivered to the edges of the donut (an example is shown in FIG. 3). In this manner the precise energy distribution can be obtained for any given treatment regime.

[0021] Persons skilled in the art will be aware that various laser energy sources are known in the art for use in low-level laser therapy. They include Helium-Neon lasers having a 632 nm wavelength and semiconductor diode lasers with a broad range of wavelengths between 600-800 nm. The laser energy source in the preferred embodiment is a semiconductor laser diode that produces light in the red range of the visible spectrum, having a wavelength of about 635 nm. Other suitable wavelengths are used for other particular applications.

[0022] The preferred embodiment is described as having a single laser energy source 11 but it will be appreciated that the invention may have two or more laser energy sources. While many LLLT regimen include ultraviolet or infrared laser light, it is

advantageous to utilize at least one laser beam in the visible energy spectrum so that the operator can see the laser light as it impinges the patient's body and the area treated can be easily defined.

[0023] Different therapy regimens require diodes of different wattages. The preferred laser diodes use less than one watt of power each to simultaneously facilitate liposuction, treat post-operative inflammation, and post-operative pain. Diodes of various other wattages may also be employed to achieve the desired laser energy for the given regimen. However, higher power lasers require a larger power source which to some extent negates the ease of handling of the hand-held wand shown in FIG. 4. It may be advantageous to provide a power source separate from the wand, and deliver the power to the wand by wire. An advantage of the present invention is that a larger treatment area can be achieved without the need for a higher power laser. Furthermore, by careful choice of beam shape, the available laser light can be used more efficiently than is achievable with the prior art LLLT devices.

[0024] Control means 13 also forms a control circuit that controls the duration of each pulse of laser light emitted and the repetition rate. When there are no pulses, a continuous beam of laser light is generated. Repetition rates from 0 to 100,000 Hz may be employed to achieve the desired effect on the patient's tissue. The goal for LLLT regimen is to deliver laser energy to the target tissue utilizing a pulse width short enough to sufficiently energize the targeted tissue and avoid thermal damage to adjacent tissue.

[0025] In order to direct the laser light to the desired area on a patient, the laser light is emitted from a lightweight, hand-held pointer referred to herein as a wand 40. As shown in FIG. 4. The wand 40 is an elongated hollow tube defining an interior cavity which is

shaped to be easily retained in a user's hand. In the preferred embodiment the laser energy source 11 is mounted in the wand's interior cavity, although the laser energy source could be remotely located and the laser light conducted by fiber optics to the wand. The wand may take on any shape that enables the laser light to be directed as needed such as tubular, T-shaped, substantially spherical, or rectangular. As mentioned above, the wand may contain the power supply (for example a battery) or the power supply may be remote with power supplied by an electrical cable. The scanning head 14 may be contained wholly within the wand 40 or may be contained within a separate fitting 41 that attaches to the end of the wand, as shown in FIG. 4.

[0026] While there has been illustrated and described what is at present considered to be a preferred embodiment of the present invention, it will be understood by those skilled in the art that various changes and modifications may be made, and equivalents may be substituted for elements thereof without departing from the true scope of the invention. Therefore, it is intended that this invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out the invention, but that the invention will include all embodiments falling within the scope of the appended claims.